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# A comparison study of hydrogen storage performances of $SmMg_{11}Ni$ alloys prepared by melt spinning and ball milling

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**Abstract:** The melt spinning (MS) and ball milling (BM) technologies are thought to be efficient to prepare nanostructured Mg and Mg-based alloys for improving their hydrogen storage performances. In this paper, two technologies, viz. melt spinning and ball milling, were employed to fabricate the $SmMg_{11}Ni$ alloy. The structure and hydrogen storage performance of these two kinds of alloys were researched in detail. The results reveal that the as-spun and milled alloys both contain nanocrystalline and amorphous structures. By means of the measurement of PCT curves, the thermodynamic parameters of the alloys prepared by MS and BM are $\Delta H_{MS}$(des) = 82.51 kJ/mol and $\Delta H_{BM}$(des) = 81.68 kJ/mol, respectively, viz. $\Delta H_{MS}$(des) > $\Delta H_{BM}$(des). The as-milled alloy shows a larger hydrogen absorption capacity as compared with the as-spun one. The as-milled alloy exhibits lower onset hydrogen desorption temperature than the as-spun one. As to the as-milled and spun alloys, the onset hydrogen desorption temperatures are 557.6 and 565.3 K, respectively. Additionally, the as-milled alloy shows a superior hydrogen desorption property than the as-spun one. On the basis of time that required by desorbing hydrogen of 3 wt.% $H_2$, the as-milled alloy needs 1488, 574, 390 and 192 s corresponding to hydrogen desorption temperatures 593, 613, 633 and 653 K, while the as-spun alloy needs 3600, 1020, 778 and 306 s corresponding to the same temperatures. The dehydrogenation activation energies of the as-milled and spun alloys are 100.31 and 105.56 kJ/mol, respectively, the difference of which is responsible for the much faster dehydriding rate of the as-milled alloy.

**Keywords:** Mg-based alloy; Melt spinning; Ball milling; Hydrogen storage kinetics; Comparison; Rare earths

## 1. Introduction

Among all the hydrogen storage materials, the metal hydride is considered as a preferred candidate that can satisfy the requirements for mobile application[1]. Mg and Mg-based alloys have been extensively investigated. Some unique advantages of these alloys make it the most promising hydrogen storage materials[2], such as high hydrogen storage capacity, good reversibility in hydrogenation/dehydrogenation process, and low cost. However, some inherent disadvantages, such as high thermal stability and poor hydriding/dehydriding kinetics, severely restrict their practical application in on-board use. Therefore, there are many obstacles to overcome for the Mg and Mg-based alloys before their widespread use as hydrogen storage materials.

Based on the summarization of numerous literatures, it is found that there are two major approaches to improvement of Mg and Mg-based alloys in hydrogen storage performance: one is to reduce the particle size, the other is to add catalysts into Mg and Mg-based alloys at the aim of forming a solid solution or Mg based composites.

Dual-tuning effect of thermodynamics and kinetics of hydrogenation and dehydrogenation processes is an important factor for the practical application of hydrogen storage materials, especially for Mg and Mg-based alloys. Many studies about this dual-tuning effects have been done[3-6]. It was proved that the thermodynamics and kinetics of hydrogen storage alloys are very sensitive to their structures[7,8]. Especially, when reducing the grain sizes far below micrometer scale, the hydrogenation/dehydrogenation properties of Mg-based alloys can be improved dramatically[9,10]. Kumar et al.[11] reported that when refining the microstructure of $Mg_2Ni$ alloy to sub 100 nm, its absorbing/desorbing hydrogen temperature will be decreased by 100 K, viz. from 573 to 473 K. Cheung et al.[12] also found that when reducing the $MgH_2$ particle to nanoscale, its stability will drop sharply. The diffusion distance for hydrogen atoms

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